Effects of Long-Duration Microgravity on Fine Motor Skills: ISS One-Year Mission

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Background

- Fine motor skills will be critical in future long-duration missions, particularly those skills needed to interact with advanced technologies in next-generation vehicles, spacesuits, and habitats.

- Studies to date on the effects of microgravity and gravitational transitions on fine motor performance have not yielded conclusive results.
  - Datasets are incomplete – timeline gaps in the microgravity data sessions
  - Studies have not focused on the fine motor actions that are likely to be required for interacting with software displays and controls (pointing, clicking, dragging, multi-touch/pinching). The majority of studies have used a joystick or arm reaching task.
  - Touchscreen tablets are already in use on ISS, and at least one commercial partner is already planning a cockpit with touchscreens as the primary means of input.

We must ensure that crewmembers are ready to perform with computer-based devices after a long-duration voyage and transition to surface operations.

Objectives

- Objective 1: Determine the effects of long-duration microgravity on fine motor performance.
  - How does fine motor performance in microgravity vary over the duration of year-long and 6-month space missions?
  - How does motor performance on orbit compare to that of a matched ground subject?

- Objective 2: Determine the effects of different gravitational transitions on fine motor performance.
  - How does performance vary before and after gravitational transitions, including the periods of early flight adaptation, and early, near-immediate postflight periods?

Subjects

	Data Collection
• 2 One-year flight subjects (1 U.S. and 1 Russian)	2 complete
• 1 One-year ground subject matched to a flight subject	1 complete
• 6 Standard duration (6-mth) flight subjects with ground matches	4 complete 2 in progress

NOTE: Ground subjects are “astronaut-like” and matched to flight subjects by age and gender. They follow the same schedule as their flight counterparts, with a lag of several weeks.

Fine Motor Skills Hardware and Software

- Data collection is accomplished using a custom Fine Motor Skills Test Battery Application on an Apple iPad3®.
  - Native iPad application installed on iPads sent to the ISS.
  - Application presents instructions, tasks, and questionnaires.
  - Data collected includes response times, errors, and X-Y coordinates.
- A custom iPad handhold is used to promote stable, standard positioning of the iPad for all sessions across subjects.
- Tasks are completed using a finger and a stylus on the touchscreen (according to onscreen instructions).
- Data are received via weekly downlinks.

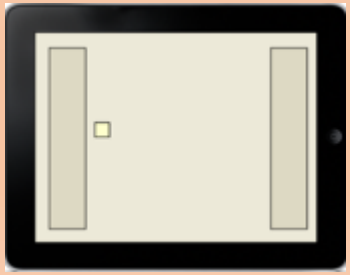
Custom handhold used during test sessions

Custom handhold and stylus in use during demonstration

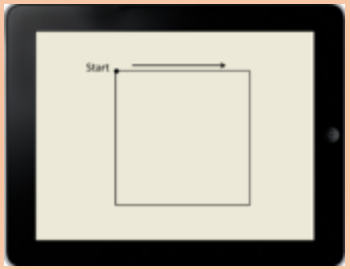
Fine Motor Skills Sessions

- Login and introductory questionnaire (4 questions)
- Test battery of 4 fine motor tasks (with variations of size and orientation)
- Instructions indicate whether finger or stylus should be used for each block of trials
- Tasks appear in a different order for each session.
- Software measures response time and accuracy.
- Data automatically sent to the server.

Multidirectional Pointing



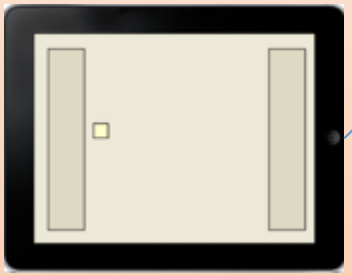
Unidirectional Dragging



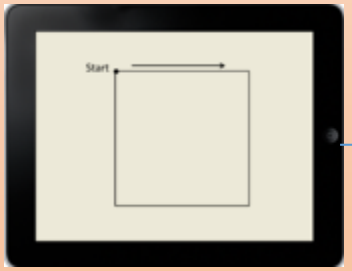
Shape Tracing

Pinch-Rotate

Rationale for Task Selection



Pointing and Dragging tasks based on ISO 9241-9 for the evaluation of cursor control devices. Includes the key interface operations of pointing, clicking, and dragging.

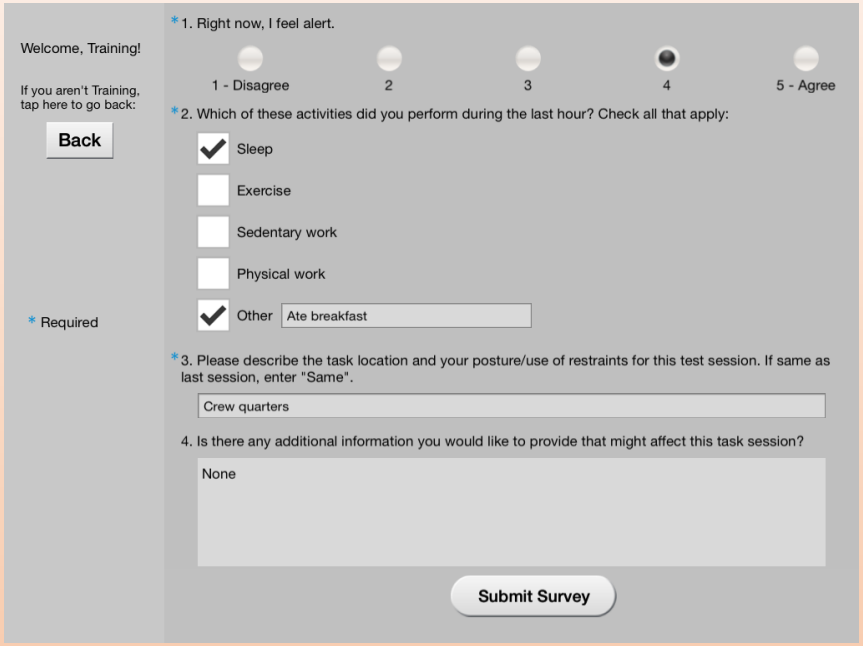


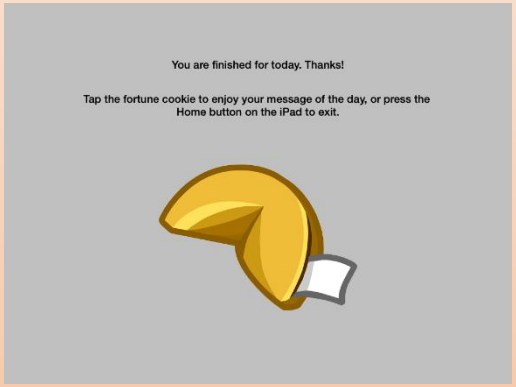
Shape Tracing is a common task for the measurement of fine motor skills, typically done with pen and paper.

Multi-touch pinch and rotate operations are common tasks on modern touch interfaces.

Questionnaires in the Software

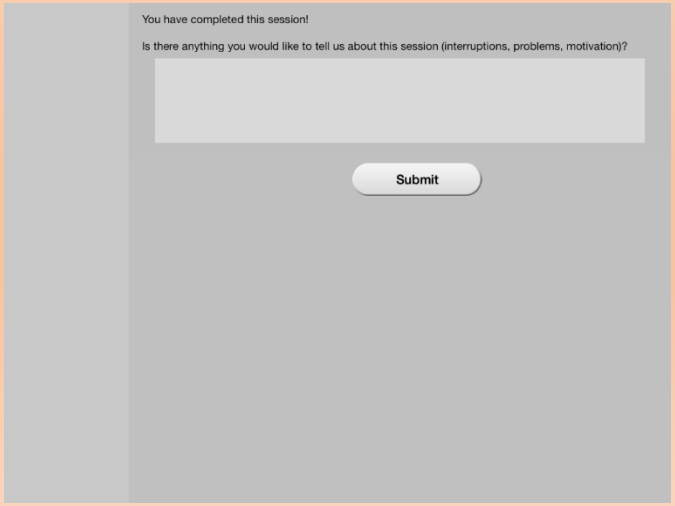
Pre-session





Fun, post-session motivator

Post-session



Data Collection Schedule and Duration

- Schedule
  - Familiarization session (~L-90)
  - Preflight (4 times within L-90 to L-60)
  - Inflight
    - As soon as possible, but no later than FD 2, 5
    - Every 5 days for the first 3 months
    - Every 14 days for the remainder of the flight
    - Last session within R-7
  - Early Postflight
    - R+0 (2), R+1, +3
  - Late Postflight
    - R+5, R+15, R+30
- Duration
  - ~15 min per session
  - ~5 min per session for early postflight sessions (R+0, R+1, R+3).
    - Shorter test battery developed to accommodate postflight crew time constraints

Quality of the 1YM Dataset

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- 1YM Crewmember #1

Number of completed or missed sessions and comments about deviations from protocol

- 1YM Crewmember #2

Number of completed or missed sessions and comments about deviations from protocol

- Ground match

Number of completed or missed sessions and comments about deviations from protocol

Statement about data challenges

About Results

- Standard duration subjects are still in progress, thus only descriptive results will be presented at this time
- Due to time constraints, only the Small Pointing and Circle Tracing task results will be presented
- Response Times for both tasks
  - RT change from baseline (median)
- Errors for Pointing Task
  - Number of extraneous (off-target) touches/Total number of touches
- Errors for Tracing Task
  - Mean deviation from target (Euclidean distance in pixels)

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Picture of Pointing Data

Picture of Tracing Data

Example data for Pointing and Tracing tasks

Small Pointing Task for Flight Crew #1

Graph showing Response Times

Graph showing Errors

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Small Pointing Task for Flight Crew #2

Graph showing Response Times

Graph showing Errors

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Circle Tracing Task for Flight Crew #1

Graph showing Response Times

Graph showing Errors

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Circle Tracing Task for Flight Crew #2

Graph showing Response Times

Graph showing Errors

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High-level Observations

Text describing high-level observations about the data

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Tentative Conclusions

- Does the transition from pre-flight to early microgravity adaptation impact fine motor performance?

  Responses to question

- Does fine motor performance change over the course of a long-duration mission?

  Responses to question

- Does the transition from long-duration flight to early postflight (1-g) impact fine motor performance?

  Responses to question

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Fine Motor Skills Investigation on the ISS 1-YR Mission

For a NASA video detailing this investigation:

http://youtu.be/-ZAcBOf6nnE

Questions?

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